Proton Beam Scrubbing Study in RHIC

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On Beam Induced Pressure Rise

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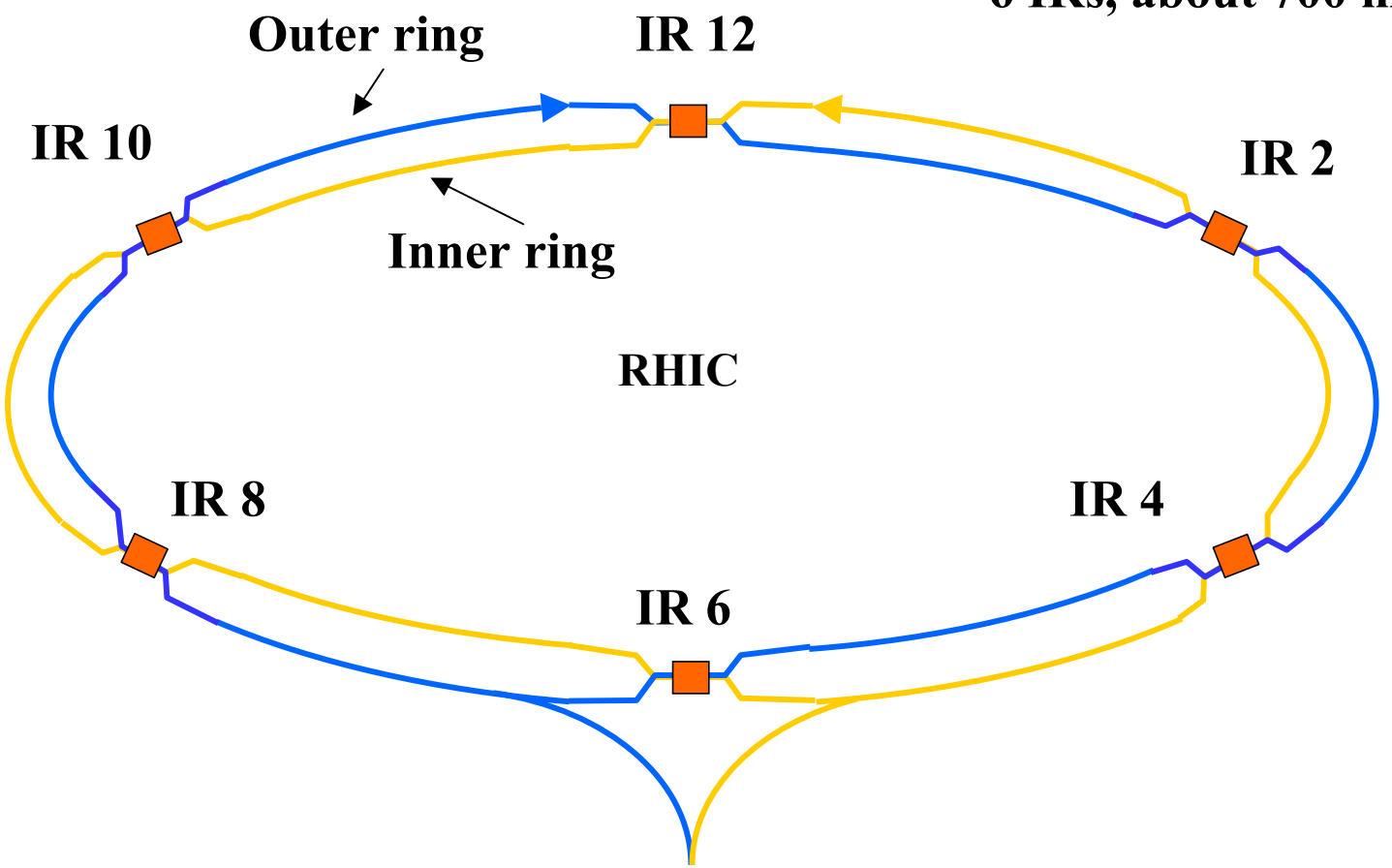
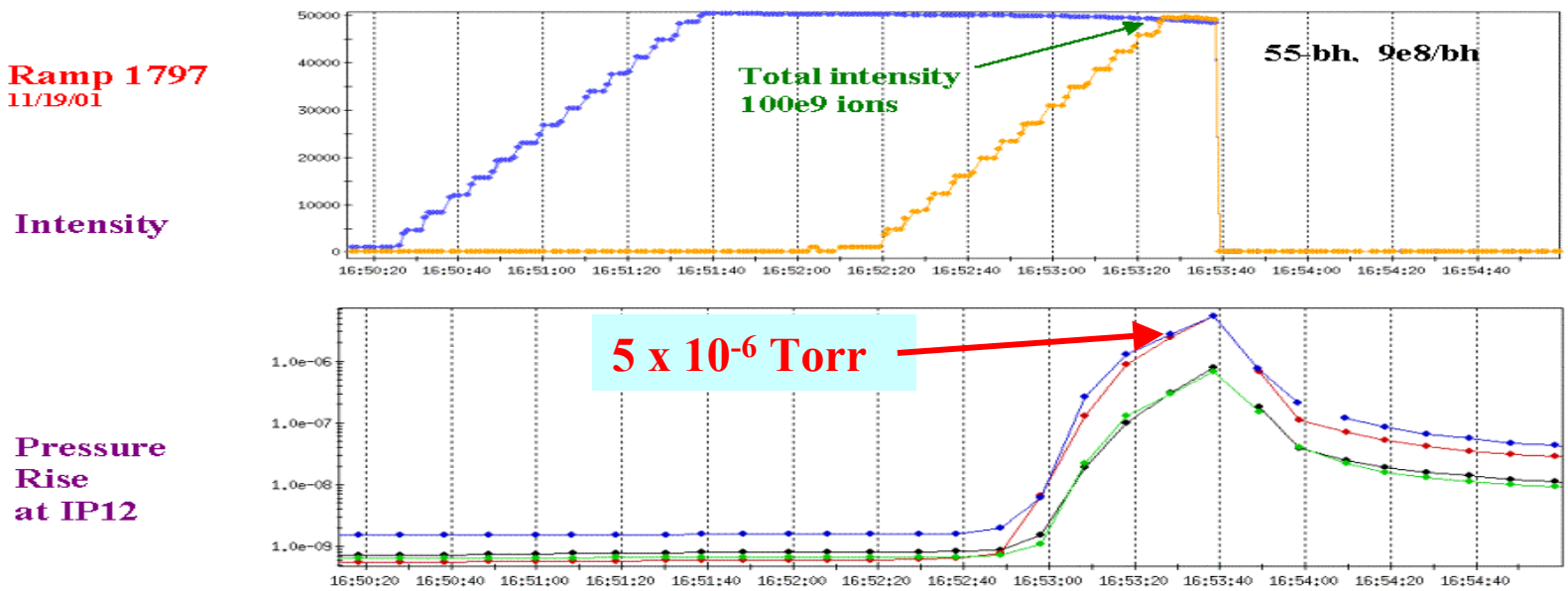
RHIC Rings

6 IRs, about 700 m warm sections



Pressure Rise Observation at RHIC Injection

- Pressure rise of several decades has been observed at injection for nominal operation conditions.
- Pressure rise is not evenly distributed, but happens mostly at warm sections and IRs.
- The pressure rise patterns are different for gold and proton beams. They are also different for different injection patterns (55 vs. 110 bunches)
- The pressure rise drops when energy ramp starts.



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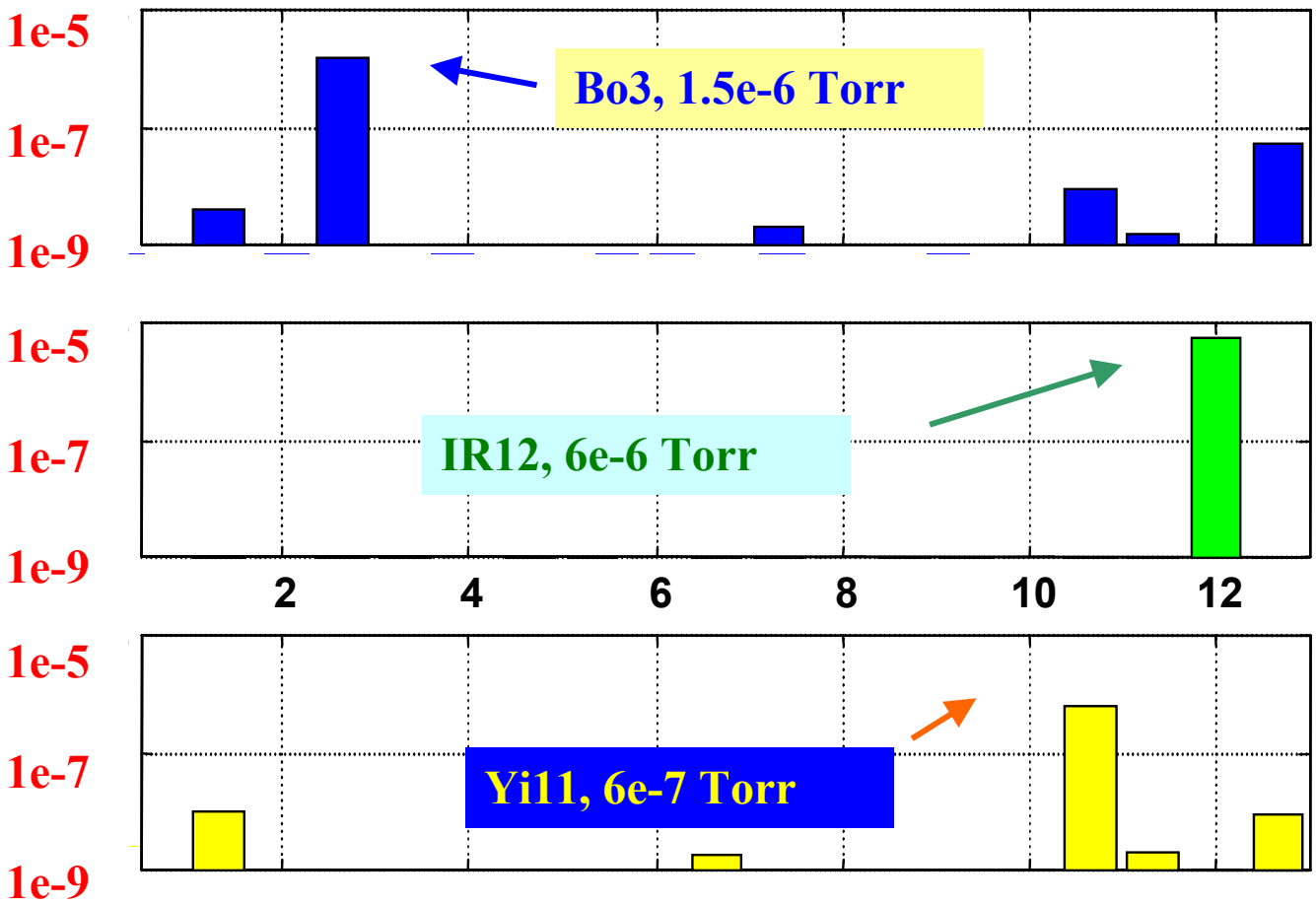
RHIC pressure rise distribution (Au beam)



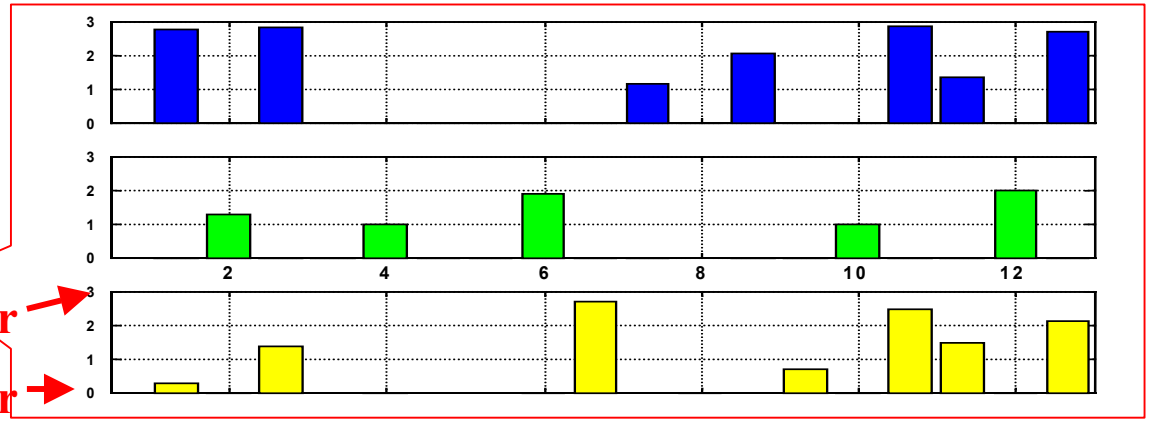
Gold Beam Ramp 1797

Proton Beam

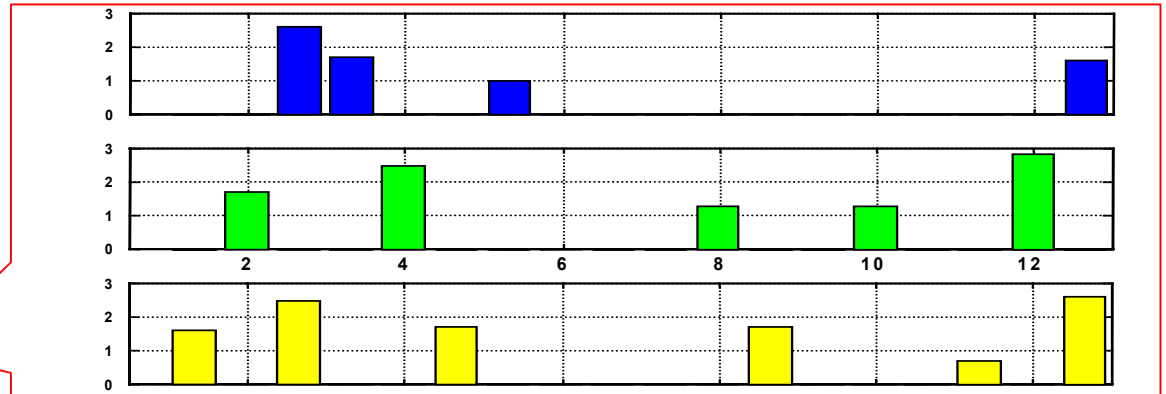
Ramp 2237, 110-bunch, 1/16/02

1e-6 Torr

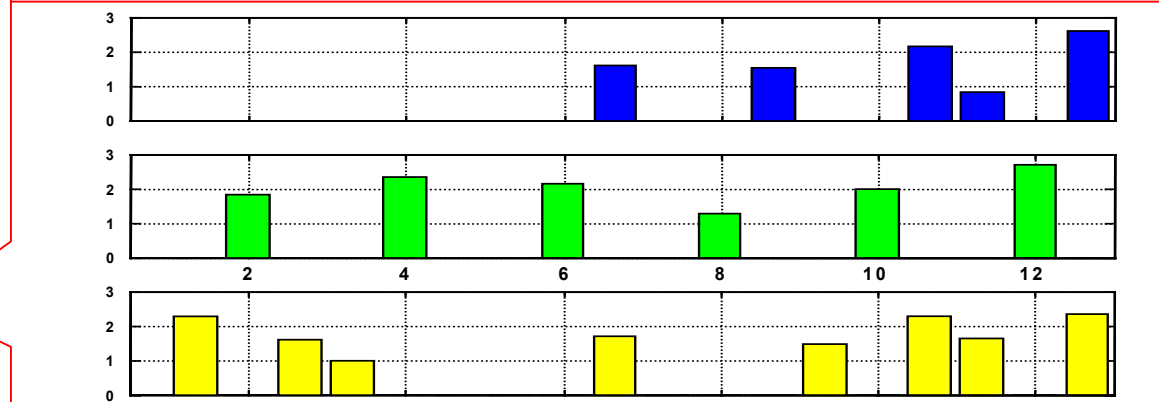
1e-9 Torr



Ramp 2158, 55-bunch, 1/6/02



Ramp 2189, 55-bunch, 1/10/02



Increase Bunch Intensity by Beam Scrubbing

Results from other accelerators

- SPS 2000 - Scrubbing at P=7 x 10^{-7} Torr, in 24 hrs, total dose 0.1mC/mm^2, pressure rise was reduced by a factor of 5.
- SPS 2002 - Scrubbing at P=5 x 10^{-6} Torr, in 24 hrs, total dose 0.5mC/mm^2, pressure rise was reduced by a factor of 100.
- PSR - Dose in 24 hrs is about 0.035mC/mm^2, estimated from the e-current on the wall. Mild pressure rise and threshold increase.

The differences between RHIC from SPS:

1. The pressure rises are localized, species dependent, bunch pattern sensitive.
2. The pressure rises are in field free area.

RHIC Beam Scrubbing Study

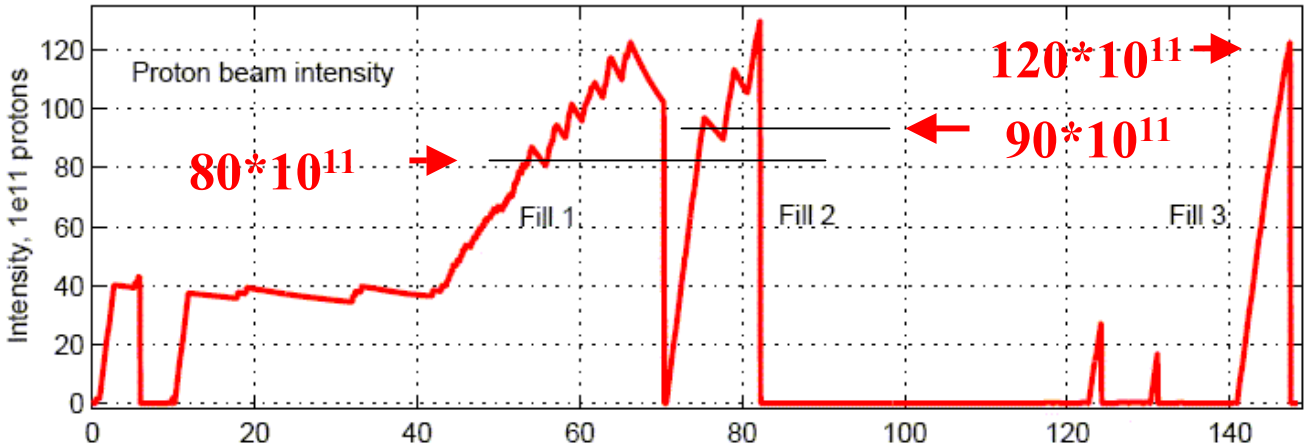
Instead of days, we only have a few hours available for beam study. Hope to answer questions such as:

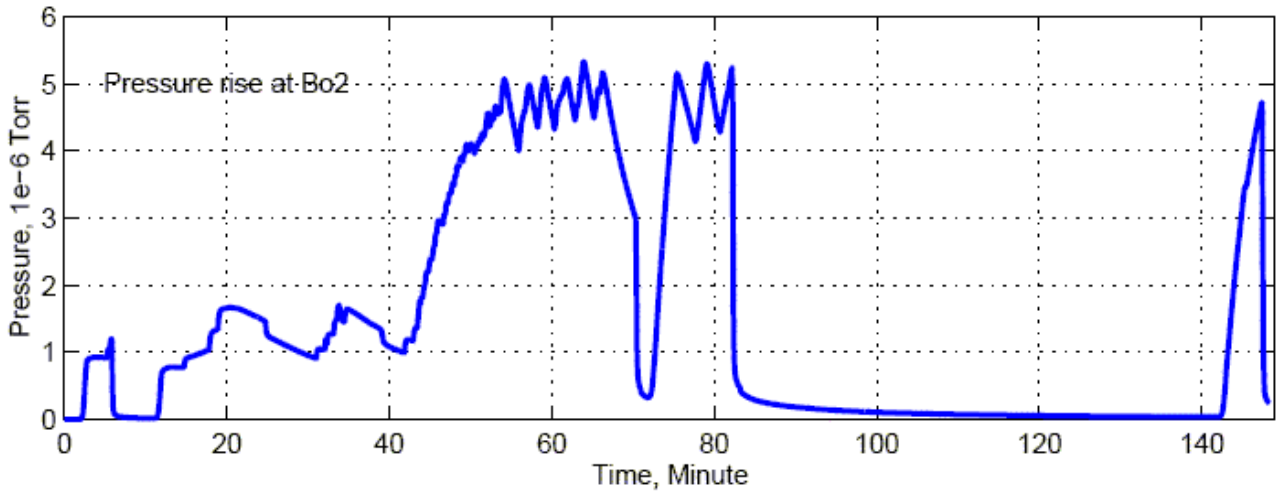
- Will scrubbing work for RHIC?
- Do we need to repeat the process for many local pressure rises?
- How efficient is the scrubbing if it works?

Method:

1. Use 110 bunch pattern in one ring. Starting from 2×10^{11} proton/bunch . Fill RHIC manually to monitor the pressure rise (1Hz signals).
2. Increase bunch number to keep pressure ($P=5\times10^{-6}$ Torr). When the pressure drops, dump the beam and refill.

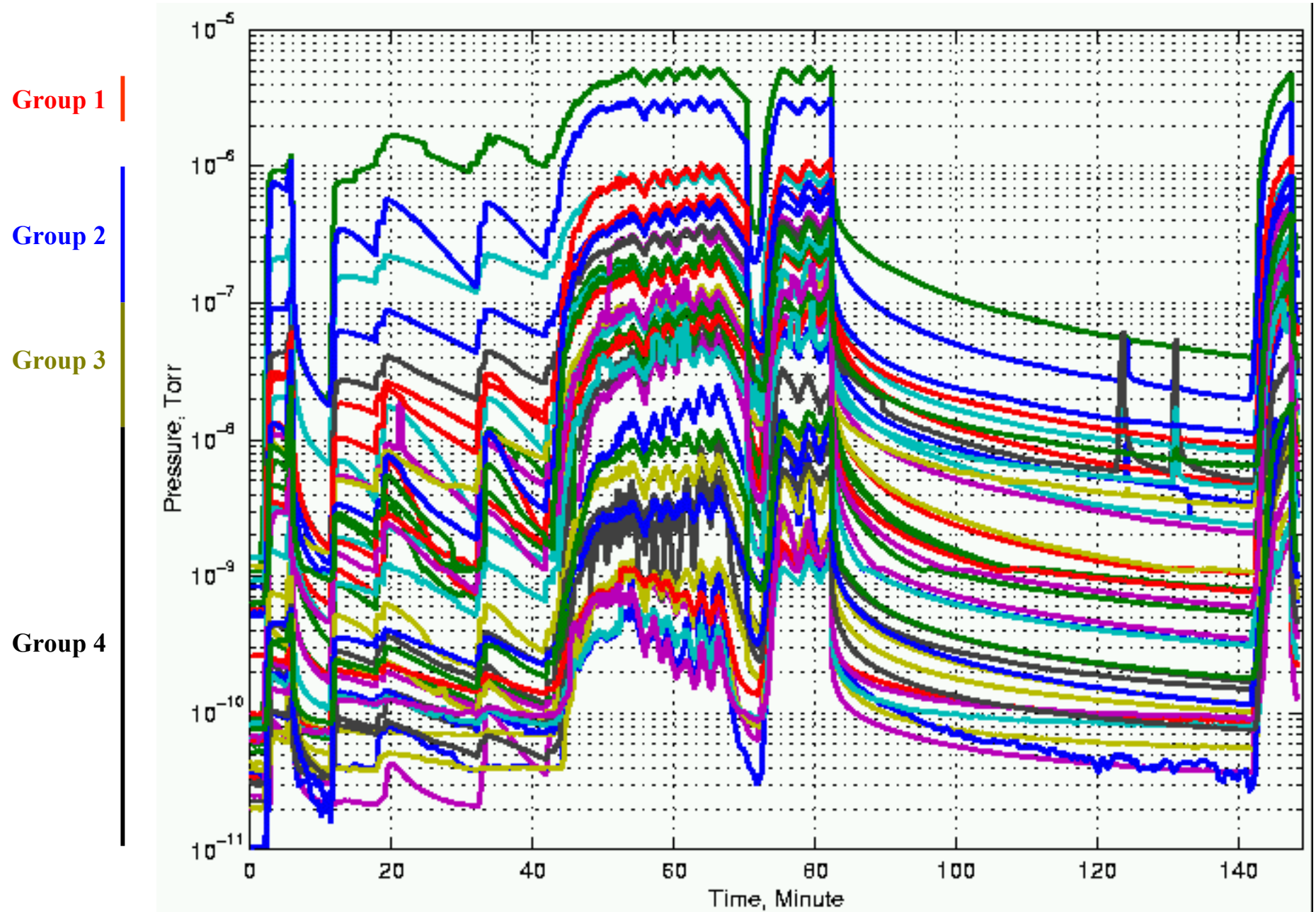
Pressure Rise at Bo2.



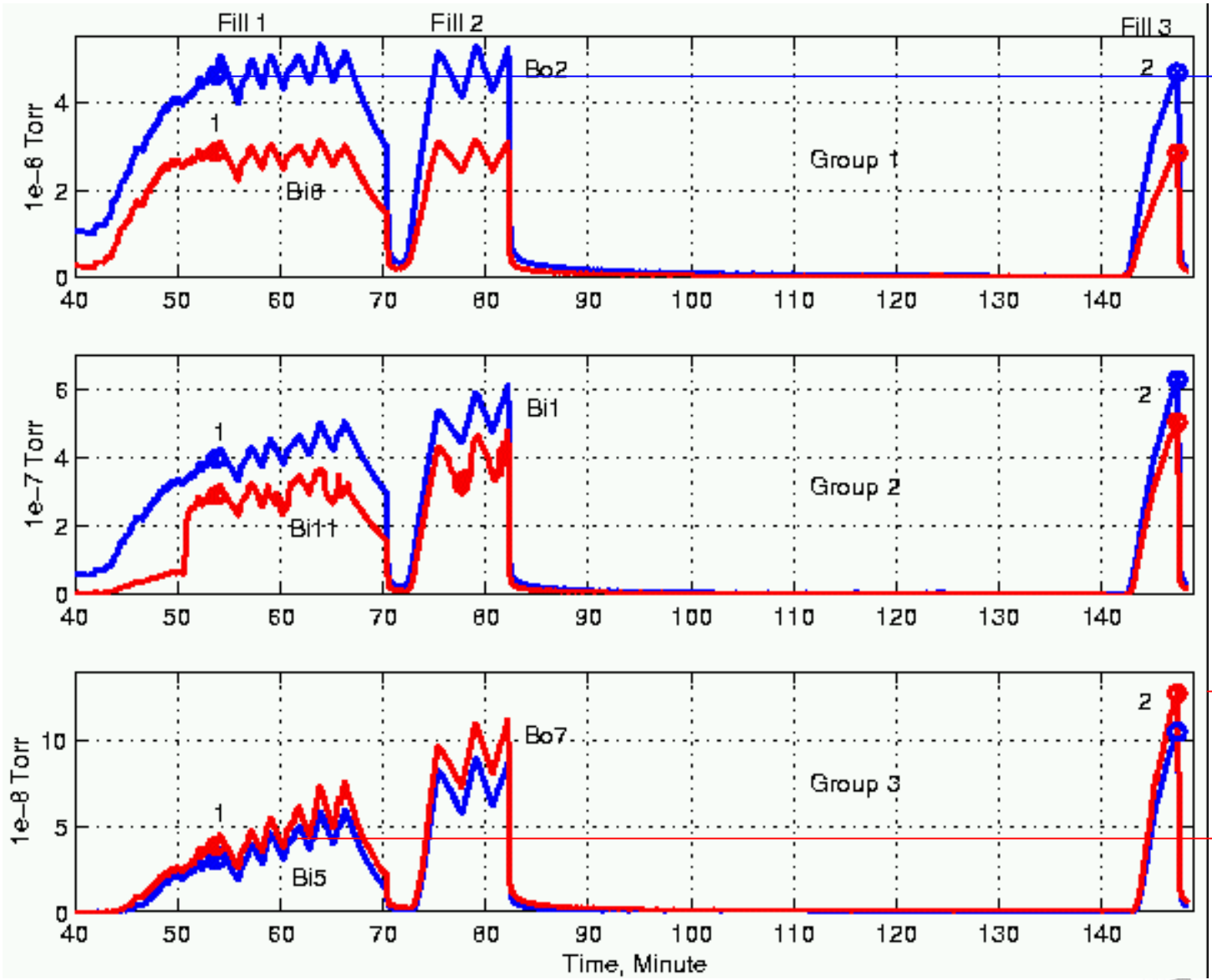


← $4.6*10^{-6}$ Torr

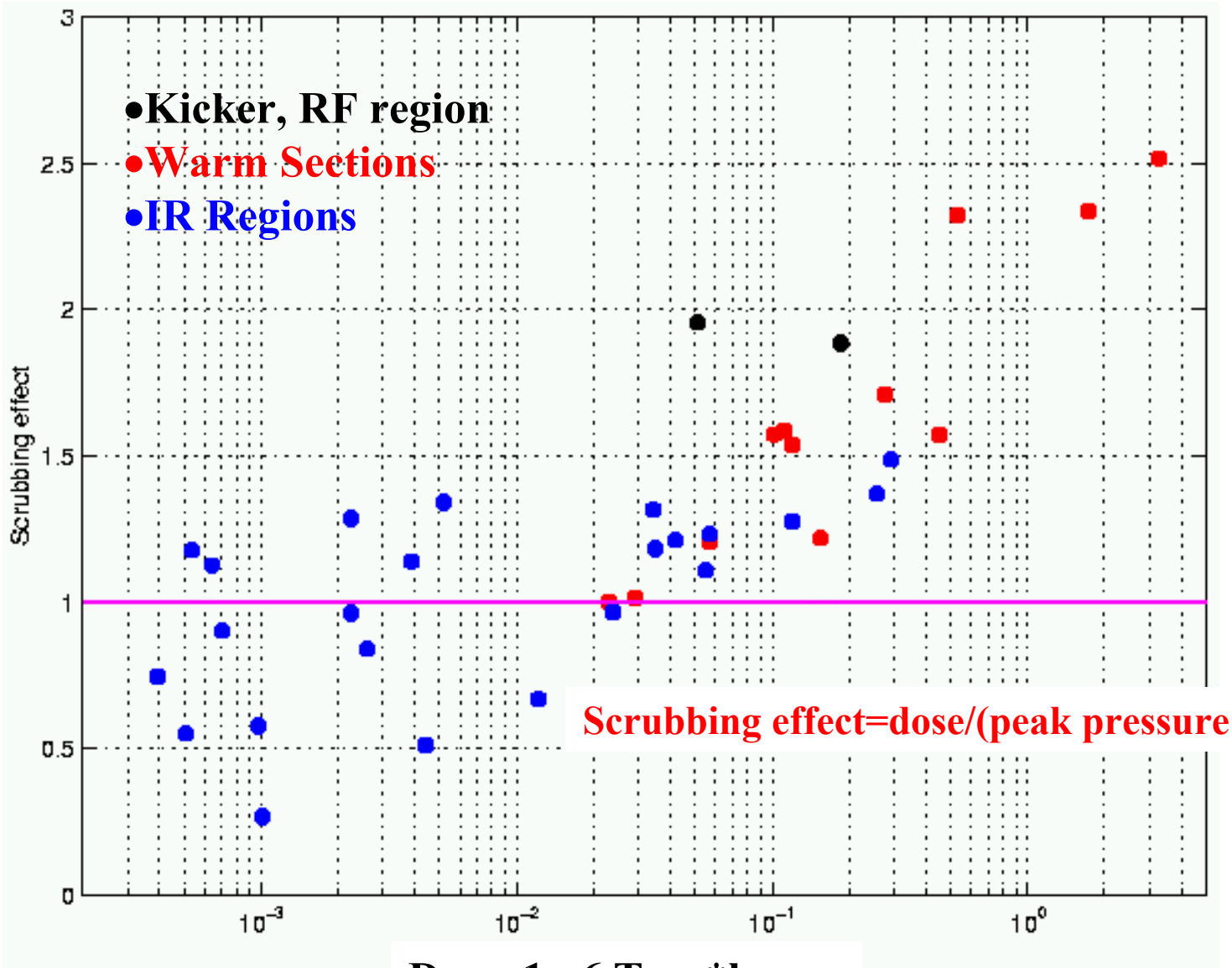
Pressure Rise at Warm Sections



High, Medium and Low Pressure Rises



Beam Scrubbing Effect



Scrubbing effect=dose/(peak pressure at fill 3)

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Summary(1)

- ✓ Consistent scrubbing effects seen at locations with pressure rise higher than 10^{-7}Torr. The higher the pressure rise, the stronger the scrubbing effect.
- ✓ Higher intensity ($120*10^{11}$) achieved at the end of the study demonstrated that it is feasible to use beam scrubbing to reach the enhanced design proton intensity.
- ✓ SPS beam scrubbing results: pressure rise of $5*10^{-6}$ Torr for 24 hrs $\Rightarrow$ dose of $120*10^{-6}$ Torr*hour resulted 100 times pressure rise reduction. RHIC study results: dose of $3.2*10^{-6}$ Torr*hour resulted 2.5 pressure rise reduction.

Summary (2)

- ✓ A 4 hours beam scrubbing (two beams) will result 15 times pressure reduction, which may be enough for $110*10^{11}$ proton beam.
- ✓ With two beams, IRs will be the hot spots. Need to evaluate the potential damages to the physics experiment detectors.
- ✓ Poor beam life time caused large loss in the ring. 30 BPM electronics in the tunnel failed on the day of scrubbing. It is under evaluation if the scrubbing can be done without damage to BPM electronics before all of them moving out of tunnel.